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THE SHAPE OF THE STERNUM IN SCORPIONS AS A SYSTEMATIC AND A PHYLOGENETIC CHARACTER

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IT is generally recognized that the shape of the sternum furnishes one of the important characters for the distinction of families in recent scorpions. The small family Bothriuridæ is the only one in which the sternum is composed of two transverse plates. This family includes seven genera, six of which occur in South America, while the seventh (*Cereophonius*) is an inhabitant of South Australia and contains a single species. The families Scorpionidæ, Vejovidæ, Chærilidæ and Chactidæ have a distinctly "pentagonal" sternum with more or less parallel sides. The Chærilidæ belong exclusively to the old world. The Chactidæ are divided into three subfamilies, the European Euscorpiinæ and the neotropical Megacorminæ and Chactinæ, which have Mexico for their northern limit of distribution. The Vejovidæ are unevenly distributed between the Old World and the New. One of the eight genera composing this family is found on the shores of the Mediterranean (*Iurus,* with a single species *I. dufoureius*), another (*Scorpiops*) with about eight species in East India. Of the remaining six genera, two occur in South America, while the other four belong to the southern and western United States and to Mexico. The family Scorpionidæ, to which some of the largest scorpions belong, has representatives from various countries and regions. It is usually divided into five subfamilies. Of these the Urodacinæ are Australian; the Scorpioninæ Asiatic and African; the Hemiscorpioninæ Asiatic; the

Ischnurinæ African, Asiatic and neotropical (*Opisthacanthus elatus* is the single neotropical species); the Diplocentrinæ neotropical and Asiatic (a single genus with two species from eastern Asia).

All scorpions belonging to the large family Buthidæ have a distinctly "triangular" sternum with converging sides and truncated apex. The family is naturally divided into two large subfamilies. Of these the Buthinæ may be regarded as belonging to the Old World, since of its 14 genera a single genus and species (*Ananteris balzani*) is found in South America. The subfamily Centrurinæ includes four genera. The genus *Isometrus* is characteristic of the Old World but its commonest species, *I. maculatus,* is cosmopolitan and occurs in Florida, Hawaiian Islands, South America, etc. *Zabius* is South American. *Titius* is neotropical, although one species, *T. floridanus,* occurs in southern Florida. The largest genus, *Centrurus,* is represented by some of the commonest species in the southern United States and the subtropical and tropical America.

Let us fix our attention for a moment on the distribution and characters of two genera of scorpions common to the United States. One is *Vejovis* (of the family Vejovidæ) and is represented in this country by six species; the other is *Centrurus* (of the family Buthidæ) and is represented by seven species. *Vejovis* belongs more to the southwest and west. It is distributed through California, Nevada, Utah, Arizona, New Mexico and Texas and extending northward into Idaho and Nebraska. A single species, *V. carolinus,* is found in the southeast. It occurs as far north as South Carolina and spreads southward to the Gulf states and Texas. Except possibly this species, the other species of *Vejovis* occur also in Mexico where the genus is represented by four additional species which do not occur in the United States. I have besides, in my private collection, a new species of *Vejovis* from Terra del Fuego. *Centrurus* belongs more to the southeast. A single species (*C. exilicauda*) occurs in

California. *C. nigrescens,* a variety of the more southern *C. gracilis,* has been reported from Texas. Four species occur in Florida, but of these *C. gracilis* and *C. margaritatus* belong to a more southern fauna, the latter being the most common scorpion of Mexico and Central America. One species, *C. infamatus,* has practically the same distribution as *Vejovis carolinus,* spreading northward into South Carolina and southward into Texas and northern Mexico. *C. infamatus* is the common scorpion of the southeast and south. Several other species of *Centrurus* are characteristic of tropical North and South America.

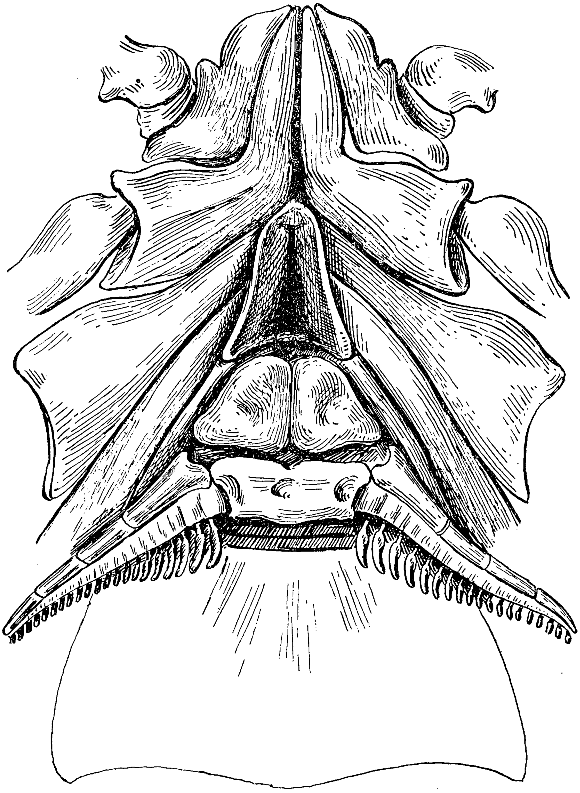

FIG. 1. Sternum, genital opercula, combs and coxæ of an adult *Centrurus insulanus* Thorell from Jamaica, W. I. The sternum is "triangular" with converging sides, but still shows traces of its original, pentagonal shape.

Vejovis carolinus is a small scorpion, its length not exceeding 34 mm. The width of the carapace at the posterior edge is slightly less than the length. The center of the eye tubercle is about ⅖ of the entire length of the carapace from its anterior edge. The sternum is pentagonal; the comb has 13–14 teeth; the central and inner rows of plates in the comb are beadlike. The fingers are rather short, being either as long as or only slightly longer than the hand.

Centrurus infamatus is usually about 45 mm. long, but large specimens measure up to 70 mm. The width of the carapace at the posterior edge is equal to or even slightly exceeds its length. The center of the eye tubercle is about ⅖ of the entire length of the carapace from its anterior edge. The sternum is triangular. The comb usually has 18–19 teeth, although their number may reach 25. The central rows of plates is not beadlike, but composed of five plates the limits between which are difficult to ascertain. The inner row is beadlike. The fingers are rather long, being more than 1½ times as long as the hand.

Let us now consider the Palæozoic scorpions. The sternum of the Silurian *Proscorpius osborni* Whitfield is unfortunately not preserved. Its nearest European relative, the Silurian scorpion *Palæophonus hunteri* Peach, has, according to Pocock, a pentagonal sternum. The sternum of the carboniferous scorpions is fairly well preserved in many specimens. The family Isobuthidæ differs from all other fossil and recent scorpions in the position of the fourth pair of coxæ which abut against the genital opercula. The sternum is either triangular (*Palæobuthus*), rhomboidal (*Isobuthus*) or oval (*Eobuthus*). The family Cyclophthalmidæ has a "pear"-shaped sternum, the family Eoscorpionidæ a distinctly pentagonal one with parallel sides. If the pear-shaped and rhomboidal impressions of sterna do not owe their shape to poor preservation or displacements, then these types of sterna must have disappeared completely, as has the type of triangular sternum found in Isobuthidæ. Of preserved fossils there remain then only the Silurian Palæophonidæ and the carboniferous Eoscorpionidæ having a sternum and arrangement of coxæ similar to that in recent scorpions. But the Silurian scorpions possessed other characters of their own and have either disappeared completely or perhaps have changed gradually into carboniferous forms. In the absence of Mesozoic fossils any attempt to trace relationships between recent and Palæozoic scorpions can be only conjectural. Thus in my "Monograph of Palæozoic Arachnida" I arrived at the conclusion (p. 26) that "the family Eoscorpionidæ shows many relations to the recent Scorpionidæ and Vejovidæ and represents probably two or three families thrown together for lack of distinctive characters." In formulating this opinion I was guided chiefly by the shape of the sternum, in several cases remarkably well preserved. Since that time I have made an observation, insignificant in itself, but one which affords an insight into the past history of recent scorpions possessing a triangular sternum and suggests a closer relationship between the Eoscorpionidæ and the Centrurinæ than between the former and the Vejovidæ. This observation was made by pure chance. While studying the problem of segmentation in Arthropods, I was examining a frontal section through a recently born *Centrurus insulanus* from Jamaica (Fig. 2). To my amazement the sternum proved to be beautifully pentagonal. An error of identification was excluded. I myself collected the material and preserved the adult females with the young carried on their back. Yet if objection should be raised, a final proof is offered by the fact that late embryos, too, have a pentagonal sternum and such embryos are easily obtainable from adult, gravid females. (Scorpions are without exception viviparous.) The young of *Centrurus infamatus* also have a pentagonal sternum, as have probably the young of all other species of the genus *Centrurus*. It is strange that no one has noticed this before, since there must be dozens of specimens in every museum. I find an interesting confirmation of my observation in Fig. 10 of McClendon's paper on the nervous system of *Centrurus infamatus*.[1] The adults of his material were identified for him by no less an authority than Kraepelin, yet in the figure in question McClendon draws a distinctly pentagonal sternum in a surface view of a late embryo. The case is the more interesting because McClendon himself is unaware of the value of his observation, nor is there the slightest reference to it in the text. He simply drew the sternum as he saw it, without so much as mentioning it. An examination of the adults of *Centrurus insulanus* (Fig. 1) as well as of other species of *Cen-*

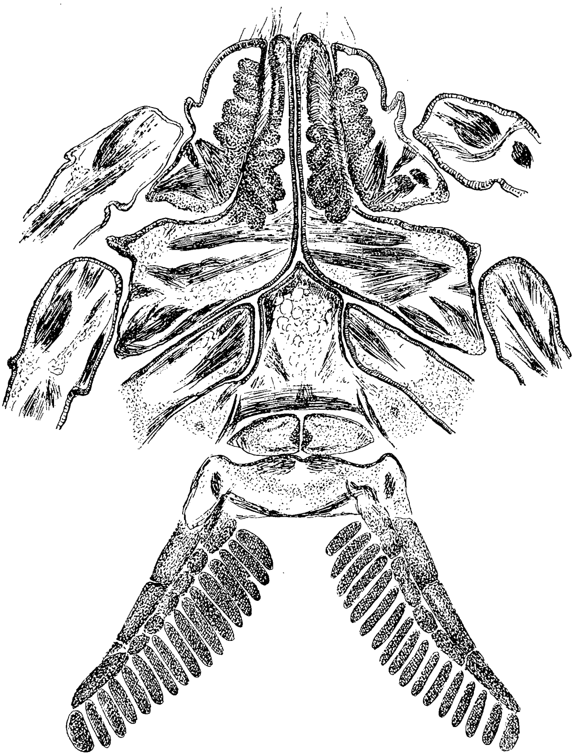

FIG. 2. Frontal section parallel to the ventral surface showing sternum, genital opercula, combs and coxæ in a very young *Centrurus insulanus*. The sternum is distinctly pentagonal, with parallel sides.

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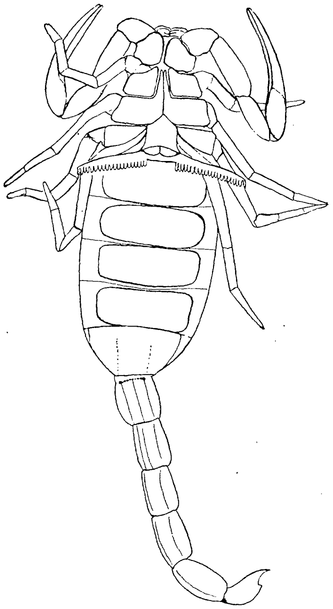
[1] *Biol. Bull.*, Vol. 8, 1904, p. 51.

trurus, shows that their sternum retains throughout life traces of its origin from a pentagonal prototype. Only the triangular apex is comparatively small and more or less hidden between the coxæ, and the sides of the sternum are strongly convergent, not parallel. The sternum in adults of various species of Buthinæ of the Old World shows also a small triangular apex hidden between the coxæ, and in the absence of material I venture the prediction that the embryos will be proved to possess a pentagonal sternum.



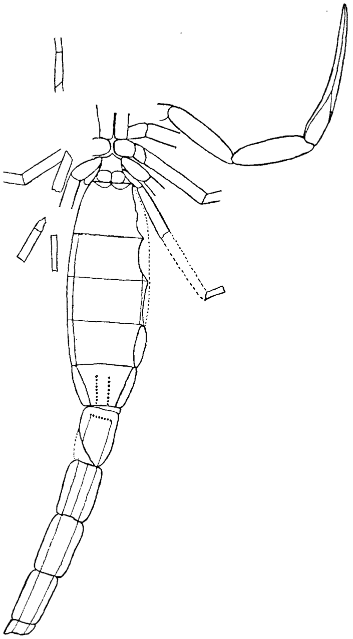


FIG. 3. A very young *Centrurus infamatus* (C. l. Koch) = (*carolinianus* Palisot de Beauvais) drawn with the aid of the Abbe apparatus. The sternum is pentagonal. The hand has much longer fingers than would be the case in an adult of the same species. Abdomen distended by yolk.

FIG. 4. *Eoscorpius typicus* Petrunkevitch, from Mason Creek, Illinois. Specimen No. 37986 of the U. S. N. M. (Fig. 6 of the Monograph.)

Keeping this in view, let us now compare *Centrurus infamatus* with *Eoscorpius typicus* of the Pennsylvanic from Mason Creek, Illinois, a rather well-preserved Palæozoic scorpion of approximately the same size. Fig. 4

is taken from my monograph and represents the holotype of *Eoscorpius typicus* as it appears on the reverse. Fig. 3 is a careful drawing of a very young *Centrurus infamatus* made with the aid of an Abbe apparatus. This figure is much more enlarged than is Fig. 4, to facilitate comparison. The shape of the abdomen, as is well known, is the least constant character and we will leave it out of consideration. To avoid criticism, however, I would state that the great distension of the abdomen in the young *Centrurus* is due to the presence of embryonic yolk. When this disappears, the abdomen becomes much thinner. In older specimens the distension of the abdomen is frequently due to the growing embryos. Yet, in dissecting what I supposed to be gravid females, I was surprised to find no embryos in them and only small ovaries. The fact is that the distension of the abdomen is also often due to the condition of the liver.

The carapace has a fairly constant shape and is similar in both scorpions. For figure and measurements I refer to my monograph. I do not reproduce them here because the carapace of *Vejovis,* except for its size, is also of similar shape. The rows of granules on the caudal segments are not sufficiently well preserved in the fossil specimens to allow of a conclusion as to their exact number. On the other hand, the transverse row of granules at the anterior end of the first caudal segment, present in *Eoscorpius* and wanting in the adult *Centrurus,* is clearly defined in the young. The most interesting character is represented in the hand with its fingers. As a rule the ratio between the length of the fingers and that of the hand is a fairly constant one for each species. In the holotype of *Eoscorpius typicus* it is approximately 2:1; in the adult *Centrurus infamatus* it is 1.6:1, but in the late embryos and just born young it also approximates 2:1. With other words, *Centrurus* developed from an ancestor with relatively longer fingers and the trend of evolution was toward reduction in their length.

One character presents a difficulty. This is the comb.

Specimen No. 37987 of the U. S. Nat. Mus. of *Eoscorpius* shows a comb which is very broad at the base, and has, apparently, a single median plate, a beadlike inner row and 19 teeth. I identified this specimen as *Eoscorpius typicus* for the reason that "the general appearance of the specimen, the shape "of the tergites, especially of the seventh," strongly resembled the holotype. The specimen is incomplete and about twice as large as the holotype. Perhaps No. 37987 is after all of a different species. The shape of the comb in recent species of *Centrurus* is not always the same as in *infamatus*. The comb in *C. junceus* and *C. agamemnon* is twice as wide at the base as in the middle.

Taking all characters and the geographic distribution into account, we can not fail to notice the greater similarity between the young of *Centrurus infamatus* and *Eoscorpius typicus* than between the latter species and *Vejovis*. What advantage, if any, *Centrurus* has derived from the shortening of the fingers and the change in the shape of the sternum, is a totally different question which may possibly be answered by studying the functions and uses of these organs in recent species.